Patented bioactive glass “scaffolds” regenerate damaged bone

Himanshu Jain and his colleagues recently received two U.S. patents for “scaffolds” of glass that regenerate diseased bone tissue. Their endeavor, which spans four continents, began in 2004, when Lehigh received an NSF grant to establish the International Materials Institute (IMI) for New Functionality in Glasses.

On a visit to Egypt in 2004, Jain, who directs the IMI, met Mona Marei, who heads the tissue engineering lab in the Faculty of Dentistry at the University of Alexandria. Marei challenged Jain to develop a glass product that could be used to treat people with deteriorating teeth and jawbones.

Jain began collaborating with Rui Almeida and Ana Marques of the Instituto Superior Tecnico in Lisbon, Portugal, on a method of making biocompatible glass. Hassan Moawad, Jain’s research associate, also joined the group and worked on a second fabrication approach.

In 2006, on a flight to Japan, Jain bumped into Matthias Falk, a Lehigh biologist with expertise in the cellular processes underlying tissue regeneration. The group later welcomed Leena Hupa of the Abo Akademi in Finland, who has a knowledge of scaffold degradation, and Jui Chakraborty of the Central Glass and Ceramic Research Institute in Kolkata, India, who is helping develop an injectable paste of the glass.

The challenge for the group was to make a biocompatible material that, when placed inside the body, would degrade at about the same rate the new tissue grows. This scaffold, tailored to the needs of the individual patient, would at the same time stimulate the regrowth of damaged or diseased bone and other hard tissue.

“Scientists have had some success in regenerating soft tissue,” says Jain. “But hard tissue is much more difficult to regrow.”

Jain’s group spent seven years designing and testing its patented glass scaffold. A critical feature of the material is a coexistent interconnected porosity at the nano- and macroscales that enables cells to proliferate and attach to the inside of the scaffold while facilitating the flow of nutrients to regenerating bone tissue and accelerating the rate at which the material decays and is absorbed by the body.

In trials conducted by Marei, the group has succeeded in regenerating the blood vessels, collagen and jawbones of animals. Jain, Almeida and Marques were awarded a patent in October for nano/macroporous bone tissue scaffolds for regenerative medicine. A second patent awarded in March for the fabrication approach devised by Moawad is based on the conventional melt-quench method of glass fabrication.

The project has received support from NSF and IMI and has provided training to more than a dozen undergraduate and graduate students.

Sabbatical benefits researcher and his students

Fresh off a sabbatical at Caltech, Jim Gilchrist is finding considerable interest in his research on particle coatings and the structure of suspensions. This summer, he will deliver invited keynote presentations on particle coatings at conferences in Washington, D.C., and Shanghai. Recently, he’s given talks in Lisbon and North Carolina on his work with suspensions, and he will give another lecture on that topic in Denmark in the near future.

His colleagues at Caltech were particularly interested in the results that Gilchrist, an associate professor of chemical engineering, has achieved in the field of suspension microstructural characterization. Using confocal laser scanning microscopy, he and his group track particles in 3-D solutions to determine their “fingerprint” and to understand how structure relates to the unusual properties of complex fluids. They strive to obtain simulation-level detail from these nanoscale measurements and use them to calculate internal stresses.

The measurements promise to enable the design of complex fluids whose properties are useful in the pharmaceutical, chemical, agricultural, food, cosmetic, ceramic, electronic and mining (hydraulic fracturing) industries. They could also shed light on natural processes like transport sediment in rivers and blood flow.

Graduate student M. Tharanga Perera, who measures suspension stress during flow, has reported unexpected particle ordering when polymer is added to solution. “The work has motivated him to produce perhaps the most accurate measurements to date of these systems,” says Gilchrist.

Alexander Weldon, a fifth-year undergrad, has given several conference presentations on the coatings research he conducts with Gilchrist. These experiences have strengthened his aspiration to be an astronaut.

“The opportunities to network and to collaborate with faculty on research,” says Gilchrist, “help pave the way for students like Tharanga and Alex to move into the next stages of their careers.”

At Caltech, Gilchrist was hosted by John F. Brady, the Chevron Professor of Chemical Engineering, who studies novel simulations of suspensions. “The experience was inspirational,” says Gilchrist. “Brady and the entire chemical engineering faculty were incredibly welcoming and supportive.”

The sabbatical also connected Gilchrist with Harry Atwater, director of Caltech’s Light-Material Interactions Energy Frontier Research Center. Gilchrist and Atwater are developing microtensile array coatings for silicon solar cells, mirroring a similar project Gilchrist has with Mark Snyder, the P.C. Rossin Assistant Professor of Chemical Engineering at Lehigh.

Confocal laser scanning microscopy helps Gilchrist track particles in solution.